CHANGES IN THE RHEOLOGICAL CHARACTERISTICS AND BAKING QUALITY OF WHEAT AT DIFFERENT MOISTURE CONTENTS STORED UNDER NITROGEN.

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ABSTRACT

Soft wheat stored at various levels of moisture content in experimental and pilot scale silos under nitrogen and air was analysed as to its rheological and baking properties.

It could be shown that preservation in partial or total anoxia of the grains never induced any impairment of the technological quality of the flour obtained either by experimental or industrial milling and analysed by farinogram, extensogram, Chopin alveogram and bread-making tests. At medium and high moisture contents a protective effect of the nitrogen atmosphere was observed.

Similar data were obtained for durum wheat stored at pilot scale in technical nitrogen.

INTRODUCTION

Evaluation of the technological quality of the material to be stored is essential for any investigation on the preservation of cereals in an inert atmosphere. Our purpose was to study the rheological characteristics of flour obtained from soft wheat stored at different humidity degrees and of durum wheat semolina.

MATERIALS AND METHODS

Soft wheat of different varieties and durum wheat were tested at natural or artificially increased moisture contents.

Parameters taken into account for the rheological study were those generally used in comprehensive investigations on doughts and thus apt to evidentiate the dough structure:

- Farinogramme (ICC Standard 115)
- Brabender extensogramme (ICC Standard 114)
- Alveogramme (ICC Standard draft 121)
- Hagberg-Perten method (ICC Standard 107)
- Baking test (Lombardi et al. 1976).

Each one of these parameters allows to evaluate different quality features of doughs; we thus judge it necessary to employ all of them.

The semolina analyses were: moisture content, proteins, gluten, farinogramme. On wheat itself a germination test and fungus count were also carried out.

Experimental milling of wheat samples was carried out with a Bühler MCK 201 mill, which, in its reduced diagramme (3 breakage cylinders and 3 re-milling cylindres), conforms perfectly to industrial mills. Industrial milling was carried out by the Pietro Agostinelli Mill, Rome.

RESULTS AND DISCUSSION

- Long term storage of dry soft wheat

Our experiments were carried out on wheat, variety "Marzotto", stored in nitrogen,atmosphere for 5 years at 10.5% initial moisture content (increased up to 12% during the second year).

After 5 years, flour of the sample stored in nitrogen was compared to that of the same wheat stored under normal air ventilation.

Comparison of the parameters (table 1) shows that:

- the degree of softening of both samples is identical
- extensigraphic indexes exhibit, on the contrary, an evident difference: increased resistance and decreased extensibility of dough from nitrogen atmosphere stored wheat, which gives an R/E ratio of particular significance (0.95)
- alveographic data also indicate that the nitrogen stored sample has a more marked tenacity
- the Hagberg-Perten index gave identical values for both samples.

Table 1 - Rheological parameters of soft wheat "C. Marzotto" flour stored in air and in nitrogen for 5 years

Parameters	After 5 years storage in air	in nitrogen
FARINOGRAMME		
Resistance (sec)	5'45"	4'30"
Degree of softening (B.U.)	95	95
EXTENSOGRAMME		
Resistance (R) (cm)	8.8	13.5
Extensibility (E) (cm)	18.3	14.1
R/E	0.47	0.95
ALVEOGRAMME		
Stability (P) (mm)	62.7	109.5
Extensibility (L) (mm)	95.0	85.0
Deformation work (W) (erg 10^3)	184.4	286.4
HAGBERG-PERTEN INDEX	392	392

The baking test has resulted in bread of normal smell and normal colour, almost undistinguishable for both samples, the only difference being the porosity (the alveoli form was more regular in the bread obtained from the sample stored in nitrogen).

Our results show that nitrogen storage had no negative effect on dough, but on the contrary improved it by increasing the R/E ratio.

- Dry soft wheat storage in a pilot scale plant

Wheat samples of variety "Marzotto", stored in silos with nitrogen atmosphere for 58 weeks, were analysed. The sufficient amount of stored wheat (22 tons) enabled us to carry out an industrial milling and thus to compare the data with those obtained by experimental milling.

By comparing time 0 and time 58 weeks (table 2) the results are:

- no difference in farinographic indexes
- elasticity increase in the nitrogen stored sample with resistance decrease further confirmed by a reduced tenacity according to the

Table 2 - Rheological parameters of flour obtained by industrial milling of soft wheat "C. Marzotto" stored in nitrogen for 58 weeks

Parameters	Time "0"	After 58 weeks
FARINOGRAMME		
Resistance (sec)	6'15"	6'30"
Degree of softening (B.U.)	80	80
EXTENSOGRAMME		
Resistance (R) (cm)	8.5	6.8
Exstensibility (E) (cm)	14.7	16.4
R/E	0.58	0.41
ALVEOGRAMME		
Stability (P) (mm)	91.7	68.5
Extensibility (L) (mm)	55.0	95.0
Deformation work (W) (erg 10^3)	176.4	187.0
HAGBERG-PERTEN INDEX	386	354

Table 3 - Rheological parameters of soft wheat "Cappelle" flour at critical moisture content at trial's start (Time "0") and after 32 weeks storage in air and in technical nitrogen

Parameters	Time "0"	After 32 weeks storage	
		in air	in nitrogen
FARINOGRAMME			
Resistance (sec)	3'00"	2'10"	1'55"
Degree of softening (B.U.)	110	110	105
EXTENSOGRAMME			
Resistance (R) (cm)	7.9	5.5	6.8
Extensibility (E) (cm)	15.6	19.7	17.7
R/E	0.50	0.28	0.39
ALVEOGRAMME			
Stability (P) (mm)	38.6	40.9	39.9
Extensibility (L) (mm)	98.0	125	88.0
Deformation work (W) (erg 10^3)	124.0	149.3	113.2
HAGBERG-PERTEN INDEX	215	174	195

alveogramme.

The baking test shows no noteworthy differences.

Nitrogen storage for one years does not affect the dough structure obtained from flour of wheat stored in this way.

- Storage of soft wheat at critical moisture content

This study concerns a French soft wheat "Cappelle" variety, stored in two different silos in air and in technical nitrogen atmosphere, at critical moisture contents (i.e. at 14.5%).

The comparison (table 3) shows:

- an essential uniformity between the degree of softening
- a higher R/E ratio of the sample stored in nitrogen with respect to the one stored in air, although both ratios are lower than the "0" time level
- reduced alveographic extensibility (L) of the nitrogen sample, while the stability value (P) is almost constant.

- Soft wheat storage at overcritical moisture content

In this experiment the same analyses were repeated on samples of different varieties stored under the above conditions (see "critical moisture content"), their moisture content having been increased artificially to the level of 17.4% to 18.0%.

The comparison (table 4) shows:

- the degree of softening indicates a better stability of the samples stored in nitrogen, except for the "Marzotto" variety
- extensigraphic data show a general increase of resistance and a decrease of extensibility with storage, which results in a higher R/E ratio. This trend is confirmed by the alveographic data on tenacity and extensibility.

An increase of the deformation work is further to be pointed out (this phenomenon being more marked in the samples stored in nitrogen atmosphere). Obviously it is higher in hard wheat and results from the higher stability of doughs obtained from stored wheat flour.

In summary, the test at overcritical moisture content revealed

Table 4 - Rheological parameters of three varieties soft wheat flours at over critical humidity at trial's start (time "0") and after 32 weeks storage in air and in technical nitrogen

	Cappelle			Red spring			Marzotto		
	0	A	N	0	A	N	0	A	N
FARINOGRAMME									
Resistance (sec)	3'00	1'10"	1'45"	5'40"	2'05"	2'25"	3'15"	1'40"	2'00"
Degree of softening (B.U.)	110	105	75	70 ,	40	30	100	60	75
EXTENSOGRAMME									
Resistance (R) (cm)	7.9	3.6	10.3	4.8	15.7	14.6	6.6	10.7	11.7
Extensibility (E) (cm)	15.6	10.4	14.3	21.4	14.5	13.0	16.3	8.5	9.2
R/E	0.50	0.35	0.73	0.22	1.08	1.12	0.40	1.26	1.27
ALVEOGRAMME									
Stability (P) (mm)	38.6	70.9	56.2	113.6	145.0	130.0	73.4	110.2	114.5
Extensibility (L) (mm)	98.0	38.0	74.0	76.0	97.0	87.0	39.0	39.5	36.0
Deformation work (W) (erg 10^3)	124.0	140.0	159.6	311.2	401.8	410.3	142.0	141.6	171.0
HAGBERG-PERTEN INDEX	215	229	201	303	406	396	389	401	413

that samples stored in air are subject to important negative changes, while the samples stored in nitrogen were affected in a lesser negative way.

- Storage of durum wheat

Durum wheat storage in nitrogen (Shejbal, 1976) was also tested. The trial, carried out on a pilot scale, concerned Italian wheat of undetermined variety, harvested in Puglia, and artificially moistened.

As can be see in table 5 it results that:

- germination capacity is reduced in air (a massive infestation of the aerated sample stored took place)
- chemical physical parameters of semolina obtained from the samples stored in air and in nitrogen are constant
- mould counts in all samples did not increase.

Table 5 - Characteristics of durum wheat and semolina at the beginning of the experiment (time "0") and after 24 weeks of storage in air and technical nitrogen

Analysis	Time "0"	After 24 weeks in air	After 24 weeks in nitrogen
H_2O (%)	13.5	13.7	13.2
Germinative capacity (%)	93	70	92
Gluten (% d.m.)	10.3	10.4	10.4
Total proteins (% d.m.) (Nx5.70)	11.6	11.4	11.5
Degree of softening (B.U.)	70	50	40

CONCLUSION

The total results of the rheological tests indicate that soft and durum wheat storage in a nitrogen atmosphere does not cause any adverse effect on the technological quality of the product, so that the use of nitrogen can be considered beneficial especially since the samples stored at high moisture contents are protected by anoxia in respect to the controls preserved in air.

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